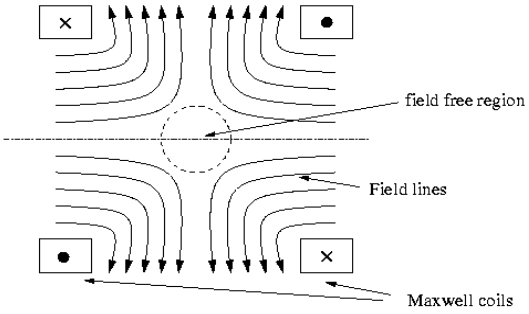
Magnetic Particle Imaging

Jürgen Weizenecker and Bernhard Gleich

Philips Research Laboratories, Hamburg, Germany
juergen.weizenecker@philips.com

Detecting magnetic material has broad applications in material science and medical imaging. In medical imaging, magnetic material serves mainly as contrast agent for magnetic resonance imaging (MRI). MRI is a powerful technique for detecting magnetic particles, but the intrinsic low signal strength and the background signal from the patient limits the imaging speed and the detectable concentration. For very low concentrations, direct detection of magnetic particles using a magnetometer becomes more sensitive. Unfortunately traditional direct detection methods suffer from a low spatial resolution.



Recently, a new method has been introduced to directly map the spatial distribution of magnetic particles. This method, called Magnetic Particle Imaging (MPI), promises high resolution and high sensitivity. It makes use of two essential features. One is a special designed magnetic field and the other a nonlinear magnetic material. The magnetic field has zero magnitude at one point and increases strongly in the vicinity of this point. At this point the magnetic material is not in saturation, whereas at all other points it is in saturation. The non-saturated state of the material is detected using an additional oscillating magnetic field. Scanning the field free point over the sample allows the direct mapping of the concentration distribution of the magnetic material within the object under consideration. To obtain high resolution and sensitivity the magnetic material must exhibit certain properties. The main requirement is that the material reaches its magnetic saturation in a low magnetic field. As the sensitivity depends on the speed of the magnetization process the material should change the magnetization via the Néel rotation and not via geometrical rotation. In the case of single domain particles these requirements impose constraints on the anisotropy and size of the particles.

In this talk MPI will be introduced starting from the underlying mechanism for the generation of the signals to full 3D imaging. The requirements of the magnetic material will be discussed in detail, as MPI needs specially designed particles.